Chemistry I: Scientific Notation

Scientific notation is the way that scientists easily handle very large numbers or very small numbers. For example, instead of writing 0.0000000056, we write $5.6 \times 10^{-9}$. So, how does this work?

We can think of $5.6 \times 10^{-9}$ as the product of two numbers: 5.6 (the digit term) and $10^{-9}$ (the exponential term).

Here are some examples of scientific notation.

| | |
|---|---|
| $10000 = 1 \times 10^{4}$ | $24327 = 2.4327 \times 10^{4}$ |
| $1000 = 1 \times 10^{3}$ | $7354 = 7.354 \times 10^{3}$ |
| $100 = 1 \times 10^{2}$ | $482 = 4.82 \times 10^{2}$ |
| $10 = 1 \times 10^{1}$ | $89 = 8.9 \times 10^{1}$ (not usually done) |
| $1 = 10^{0}$ | |
| $1/10 = 0.1 = 1 \times 10^{-1}$ | $0.32 = 3.2 \times 10^{-1}$ (not usually done) |
| $1/100 = 0.01 = 1 \times 10^{-2}$ | $0.053 = 5.3 \times 10^{-2}$ |
| $1/1000 = 0.001 = 1 \times 10^{-3}$ | $0.0078 = 7.8 \times 10^{-3}$ |
| $1/10000 = 0.0001 = 1 \times 10^{-4}$ | $0.00044 = 4.4 \times 10^{-4}$ |

As you can see, the exponent of 10 is the number of places the decimal point must be shifted to give the number in long form. A **positive** exponent shows that the decimal point is shifted that number of places to the right. A **negative** exponent shows that the decimal point is shifted that number of places to the left.

In scientific notation, the digit term indicates the number of significant figures in the number. The exponential term only places the decimal point. As an example,

$$46600000 = 4.66 \times 10^{7}$$

This number only has 3 significant figures. The zeros are not significant; they are only holding a place. As another example,

$$0.00053 = 5.3 \times 10^{-4}$$

This number has 2 significant figures. The zeros are only place holders.

**How to do calculations:**

**On your scientific calculator:**

**Make sure that the number in scientific notation is put into your calculator correctly**.
**Read** the directions for your particular calculator. For inexpensive scientific calculators:

1. Punch the number (the digit number) into your calculator.
2. Push the EE or EXP button. Do **NOT** use the x (times) button!!
3. Enter the exponent number. Use the +/- button to change its sign.
4. Voila! Treat this number normally in all subsequent calculations.

To check yourself, multiply $6.0 \times 10^5$ times $4.0 \times 10^3$ on your calculator. Your answer should be $2.4 \times 10^9$.
**On your cheap non-scientific calculator:**
You will need to be familiar with exponents since your calculator cannot take care of them for you. For an introduction to rules concerning exponents, see the section on Manipulation of Exponents.
**Addition and Subtraction:**

- All numbers are converted to the same power of 10, and the digit terms are added or subtracted.
- Example: $(4.215 \times 10^{-2}) + (3.2 \times 10^{-4}) = (4.215 \times 10^{-2}) + (0.032 \times 10^{-2}) = 4.247 \times 10^{-2}$
- Example: $(8.97 \times 10^4) - (2.62 \times 10^3) = (8.97 \times 10^4) - (0.262 \times 10^4) = 8.71 \times 10^4$

**Multiplication:**

- The digit terms are multiplied in the normal way and the exponents are added. The end result is changed so that there is only one nonzero digit to the left of the decimal.
- Example: $(3.4 \times 10^6)(4.2 \times 10^3) = (3.4)(4.2) \times 10^{(6+3)} = 14.28 \times 10^9 = 1.4 \times 10^{10}$ (to 2 significant figures)
- Example: $(6.73 \times 10^{-5})(2.91 \times 10^2) = (6.73)(2.91) \times 10^{(-5+2)} = 19.58 \times 10^{-3} = 1.96 \times 10^{-2}$
  (to 3 significant figures)

**Division:**

- The digit terms are divided in the normal way and the exponents are subtracted. The quotient is changed (if necessary) so that there is only one nonzero digit to the left of the decimal.
- Example: $(6.4 \times 10^{6})/(8.9 \times 10^{2}) = (6.4)/(8.9) \times 10^{(6-2)} = 0.719 \times 10^{4} = 7.2 \times 10^{3}$ (to 2 significant figures)
- Example: $(3.2 \times 10^{3})/(5.7 \times 10^{-2}) = (3.2)/(5.7) \times 10^{3-(-2)} = 0.561 \times 10^{5} = 5.6 \times 10^{4}$ (to 2 significant figures)

**Powers of Exponentials:**

- The digit term is raised to the indicated power and the number that indicates the power multiplies the exponent.
- Example: $(2.4 \times 10^{4})^{3} = (2.4)^{3} \times 10^{(4x3)} = 13.824 \times 10^{12} = 1.4 \times 10^{13}$ (to 2 significant figures)
- Example: $(6.53 \times 10^{-3})^{2} = (6.53)^{2} \times 10^{(-3)x2} = 42.64 \times 10^{-6} = 4.26 \times 10^{-5}$ (to 3 significant figures)

**Roots of Exponentials:**

- Change the exponent if necessary so that the number is divisible by the root. Remember that taking the square root is the same as raising the number to the one-half power.
- Example:

$$\sqrt{3.6 \times 10^{5}} = \sqrt{36 \times 10^{4}} = \sqrt{36} \times \sqrt{10^{4}} = 6.0 \times 10^{2}$$

- Example:

$$\sqrt[3]{7.3 \times 10^{-8}} = \sqrt[3]{73 \times 10^{-9}} = \sqrt[3]{73} \times \sqrt[3]{10^{-9}} = 1.9 \times 10^{-3}$$